biology and life sciences forum

MDPI

Proceedings

Promoting Legume Consumption: Strategies for Health, Nutrition, and Culinary Applications †

Mauro Lombardo[1] *, Angela Ascione[1], Alessandra Feraco[1,2], Elisabetta Camajani[1,2], Stefania Gorini[1,2], Andrea Armani[1,2], Massimiliano Caprio[1,2] and Isaac Amoah[3]

[1] Department of Human Sciences and Promotion of the Quality of Life, San Raffaele Open University, Via di Val Cannuta, 247, 00166 Rome, Italy
[2] Laboratory of Cardiovascular Endocrinology, IRCCS San Raffaele Pisana, Rome, Italy.
[3] Department of Biochemistry and Biotechnology, Kwame Nkrumah University of Science and Technology, Kumasi 0023351, Ghana
* Correspondence: mauro.lombardo@uniroma5
† Presented at "The 4th International Electronic Conference on Foods", Session "Functional Foods, Nutrition and Health"

Abstract: Legumes, as functional foods, face barriers to consumption despite their undeniable benefits. The presentation exposes innovative strategies: through methods such as soaking, sprouting and the application of advanced technologies, anti-nutrients are reduced and digestibility is improved. Extrusion allows the creation of enriched functional foods. Culinary approaches, such as inclusion in salads and hummus, amplify palatability. Synergies with bioactive compounds are investigated for targeted results. These educational actions promote sustainable environmental choices. The combination of science, culinary and education promotes the acceptance and use of legumes, leading to improved quality of diet and health benefits.

Keywords: legumes; functional foods; nutrition; health; consumption; digestibility; nutritional profile; culinary approaches; sustainable food; nutrition education; bioactive compounds

1. Introduction

Legumes are functional foods that offer significant potential for improving health and nutrition. [1] However, there are several barriers that limit the widespread consumption of legumes despite their numerous health benefits and nutrient density. [2] This presentation focuses on scientifically sound strategies to address these barriers and increase the intake of legumes in the context of functional foods, nutrition and health. The presentation highlights the nutritional and health benefits associated with the consumption of legumes, emphasising their functional properties and their potential to support specific health outcomes. It also explores the role of nutrition education and awareness-raising campaigns in promoting legumes, considering their impact on sustainable food choices and environmental sustainability. The integration of scientific knowledge, culinary experience and educational approaches can contribute to greater acceptance and use of legumes as functional foods. [3] This, in turn, can improve health and nutrition outcomes. The presentation also explores the scientific evidence supporting the role of legumes in the treatment of specific health conditions, such as cardiovascular disease, diabetes, cancer, neurodegenerative disorders and gastrointestinal health. Furthermore, it analyses the bioactive compounds present in legumes and their mechanisms of action, highlighting the potential in the development of functional foods targeted at specific health problems. Finally, the synergistic effects of legumes in combination with other functional

ingredients, such as herbs, spices and probiotics, are explored to further enhance their functional properties.

2. The Nutritional Power and Health Benefits of Legumes

The nutritional composition of legumes plays a pivotal role in their potential health benefits and consumer preferences. Legumes are notably rich in protein and fiber, with reported protein and fiber contents varying across different types, such as common soybeans, beans, lentils, and chickpeas.[4] The high protein content of legumes holds promise for their incorporation into foods with lower protein content. Despite being classified as second-class proteins, efforts to enhance their digestibility can improve their competitiveness with animal-derived proteins. Additionally, their high fiber content makes them attractive for glycemic control and inducing satiety. Cooking methods influence legume nutritional profiles. Household cooking methods result in increased protein and fiber content compared to canning. Cooking losses due to protein leaching into water should be considered. [5] Beyond their nutritional content, legumes contain bioactive compounds like polyphenols, saponins, enzyme inhibitors, and phytates. These bioactives offer potential health benefits, turning legumes into functional foods. Their effects on health encompass anti-inflammatory, antioxidant, and cardiovascular benefits, among others.

Legume consumption has demonstrated significant health benefits across various domains. [6] Recent analyses highlight that increased legume intake is linked to reduced cardiovascular disease (CVD) risk, including coronary heart disease and strokes. These benefits stem from legumes' impact on cholesterol levels, aided by soluble fibers that inhibit bile acid recycling and saponins that modulate cholesterol concentrations. Moreover, legumes offer promise in diabetes management by controlling postprandial glucose and insulin responses. Their high fiber and resistant starch content, coupled with protein and low glycemic index, regulate appetite, improve insulin sensitivity, and lower blood glucose levels. In addition, legumes exhibit potential against obesity due to their satiating properties, affecting digestion and nutrient absorption. These versatile foods also showcase anticancer properties, attributed to their bioactive compounds, vitamins, and minerals, while their prebiotic potential contributes to gut health by promoting beneficial bacteria. Lastly, legumes' polyphenols counter oxidative stress and inflammation, making them valuable additions to diets aimed at preventing chronic diseases.

3. Fostering Legume Consumption: Overcoming Barriers and Promoting Increased Intake

The barriers to legume consumption are multifaceted and impact their dietary intake globally. Despite the nutritional benefits of legumes, there has been a decline in their consumption worldwide, especially in high-income countries. This decline is attributed to several factors, including confusion about serving sizes, grouping with other food categories in dietary guidelines, and lack of clarity about their health benefits. [7] To address this issue, a simple and clear directive to consume legumes daily has proven effective in promoting their consumption. Furthermore, barriers include psychosocial and socio-economic reasons. Food neophobia, characterized by resistance to trying new foods, contributes to the reluctance to consume less familiar types of legumes. [8] Additionally, food taboos, driven by religious and traditional beliefs, hinder legume consumption in various regions. Socio-economic factors, such as the time required for legume preparation, also impact consumption patterns, especially in rapidly urbanizing areas. Digestibility and health-related concerns present another set of barriers. Non-digestible carbohydrates and anti-nutrients in legumes can lead to digestive discomfort, including bloating and diarrhea. Alpha-galactosides, present in legumes, can cause digestive issues due to their fermentation in the colon. Anti-nutrients such as protease inhibitors, lectins, phytic acid, oxalate and saponins may reduce the bioavailability of some nutrients. [9,10] One of the strategies proposed in the useful years concerns the pre-processing methods of legumes,

such as soaking, sprouting and pulsed electric field. These methods effectively reduce anti-nutritional factors in pulses and cooking time, thus improving their digestibility. In addition, extrusion technology enables the development of functional food products enriched with pulses, expanding the possibilities of using pulses beyond traditional preparations. While it is true that the extrusion process has often been linked to the production of ultra-processed foods with compromised nutritional quality, it's important to note that the application of this technology can vary significantly. In the context of legumes, extrusion can be carefully calibrated to preserve, and in some cases even enhance, the nutritional profile of the end product [11]. Advanced extrusion techniques allow for the reduction of anti-nutritional factors while maintaining the integrity of essential nutrients [12]. Thus, the nutritional quality of extruded legume products can be optimized through careful selection of extrusion parameters, rather than being inherently compromised by the process itself. Culinary techniques play also an important role in making pulses more palatable and versatile. For instance, incorporating legumes into stews, salads, sprouts, soups, hummus and desserts with legume flour can increase the palatability of these foods. [13,14] In the context of legume consumption, Table 2 presents an overview of the various barriers hindering legume consumption and the corresponding strategies proposed to overcome these barriers. The guidelines [15] suggest consuming a serving of legumes at least 2-3 times per week to take advantage of their numerous health benefits. A standard serving size is approximately one cup of cooked legumes, which provides a rich source of protein, fiber, and essential nutrients. For those looking to maximize the health benefits discussed in this paper, such as improved cardiovascular health and better glycemic control, increasing the frequency of legume consumption to 3-4 times per week is recommended. These recommendations are in line with current dietary guidelines and aim to make the health advantages of legumes more accessible to the general population. It's worth noting that these guidelines can be adapted to individual dietary needs and preferences, offering a flexible approach to improving diet quality.

4. Conclusions

Legumes stand as nutritionally dense food sources containing essential nutrients and bioactive compounds that offer notable health benefits. Nutrition professionals should highlight the nutritional value of legumes and suggest the increase of their use also in high-calorie diets. Strategies such as pretreatment methods can improve gastrointestinal discomfort and reduce cooking times. Leveraging extrusion technology to create innovative legume-enriched products presents an avenue for intervention, necessitating collaboration between policymakers and food manufacturers. Promoting culinary skills through education and recipe development, particularly in schools and communities, empowers individuals to integrate legumes into their diets. Future research should explore innovative methods to enhance legume digestibility and reduce cooking time for less utilized varieties, supported by policy funding and collaboration with research institutions. Overall, a comprehensive policy approach is vital to overcome barriers and harness opportunities for increased legume consumption, leading to improved public health outcomes.

Author Contributions: Conceptualization, M.L and I.A.; methodology, M.L, M.C. .; software, A.F. and E.C.; writing—original draft preparation, M.L, S.G., I.A. and Ang. Asc. ; writing—review and editing, M.L and And. Arm. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding

Institutional Review Board Statement: Not applicable

Informed Consent Statement: Not applicable

Data Availability Statement: Data Availability Statement: The datasets produced and analyzed during the present study are obtainable from the corresponding author upon reasonable request .

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Schmidt, H.d.O.; Oliveira, V.R.d. Overview of the Incorporation of Legumes into New Food Options: An Approach on Versatility, Nutritional, Technological, and Sensory Quality. Foods 2023, 12, 2586. https://doi.org/10.3390/foods12132586
2. Geraldo R, Santos CS, Pinto E, Vasconcelos MW. Widening the Perspectives for Legume Consumption: The Case of Bioactive Non-nutrients. Front Plant Sci. 2022 Feb 10;13:772054. doi: 10.3389/fpls.2022.772054. PMID: 35222459; PMCID: PMC8866194.
3. Angeles, J.G.C.; Villanueva, J.C.; Uy, L.Y.C.; Mercado, S.M.Q.; Tsuchiya, M.C.L.; Lado, J.P.; Angelia, M.R.N.; Bercansil-Clemencia, M.C.M.; Estacio, M.A.C.; Torio, M.A.O. Legumes as Functional Food for Cardiovascular Disease. Appl. Sci. 2021, 11, 5475. https://doi.org/10.3390/app11125475
4. Schmidt, H.d.O.; Oliveira, V.R.d. Overview of the Incorporation of Legumes into New Food Options: An Approach on Versatility, Nutritional, Technological, and Sensory Quality. Foods 2023, 12, 2586. https://doi.org/10.3390/foods12132586
5. Margier M, Georgé S, Hafnaoui N, Remond D, Nowicki M, Du Chaffaut L, Amiot MJ, Reboul E. Nutritional Composition and Bioactive Content of Legumes: Characterization of Pulses Frequently Consumed in France and Effect of the Cooking Method. Nutrients. 2018 Nov 4;10(11):1668. doi: 10.3390/nu10111668. PMID: 30400385; PMCID: PMC6266829.
6. Sri Harsha, P.S.C., Wahab, R.A., Garcia-Aloy, M. et al. Biomarkers of legume intake in human intervention and observational studies: a systematic review. Genes Nutr 13, 25 (2018). https://doi.org/10.1186/s12263-018-0614-6
7. Hughes, J.; Pearson, E.; Grafenauer, S. Legumes—A Comprehensive Exploration of Global Food-Based Dietary Guidelines and Consumption. Nutrients 2022, 14, 3080. https://doi.org/10.3390/nu14153080
8. Dovey TM, Staples PA, Gibson EL, Halford JC. Food neophobia and 'picky/fussy' eating in children: a review. Appetite. 2008 Mar-May;50(2-3):181-93. doi: 10.1016/j.appet.2007.09.009. Epub 2007 Sep 29. PMID: 17997196.
9. Ferreira H, Vasconcelos M, Gil AM, Oliveira B, Varandas E, Vilela E, Say K, Silveira J, Pinto E. Impact of a daily legume-based meal on dietary and nutritional intake in a group of omnivorous adults. Nutr Bull. 2023 Jun;48(2):190-202. doi: 10.1111/nbu.12613. Epub 2023 Apr 18. PMID: 37070278.
10. Meyer-Rochow, V.B. Food taboos: their origins and purposes. J Ethnobiology Ethnomedicine 5, 18 (2009). https://doi.org/10.1186/1746-4269-5-18
11. Pasqualone, A.; Costantini, M.; Coldea, T.E.; Summo, C. Use of Legumes in Extrusion Cooking: A Review. Foods 2020, 9, 958. https://doi.org/10.3390/foods9070958
12. Geraldo R, Santos CS, Pinto E, Vasconcelos MW. Widening the Perspectives for Legume Consumption: The Case of Bioactive Non-nutrients. Front Plant Sci. 2022 Feb 10;13:772054. doi: 10.3389/fpls.2022.772054. PMID: 35222459; PMCID: PMC8866194.
13. Acquah C, Ohemeng-Boahen G, Power KA and Tosh SM (2021) The Effect of Processing on Bioactive Compounds and Nutritional Qualities of Pulses in Meeting the Sustainable Development Goal 2. Front. Sustain. Food Syst. 5:681662. doi: 10.3389/fsufs.2021.681662
14. Samtiya, M., Aluko, R.E. & Dhewa, T. Plant food anti-nutritional factors and their reduction strategies: an overview. Food Prod Process and Nutr 2, 6 (2020). https://doi.org/10.1186/s43014-020-0020-5
15. Hughes, J.; Pearson, E.; Grafenauer, S. Legumes—A Comprehensive Exploration of Global Food-Based Dietary Guidelines and Consumption. Nutrients 2022, 14, 3080. https://doi.org/10.3390/nu14153080

Tables

Table1 - Nutritional Composition, Cooking Methods, Bioactive Compounds, and Health Benefits of Various Legumes

Legume Type	Protein Content (per 100g)	Fiber Content (per 100g)	Cooking Methods	Bioactive Compounds	Health Benefits
Soybeans	~36g	~9g	Boiling, Roasting	Isoflavones, Saponins	Cardiovascular health, Hormone regulation

Beans (e.g., Kidney, Black)	**~26g**	**~15-25g**	**Boiling, Pressure Cooking**	**Polyphenols, Resistant Starch**	**Blood sugar control, Digestive health**
Lentils	**~24.6g**	**~10.8g**	**Boiling, Simmering**	**Polyphenols, Phytates**	**Satiety, Improved gut health**
Chickpeas	**~25g**	**~17g**	**Boiling, Roasting**	**Saponins, Polyphenols**	**Weight management, Digestive health**

Note: The nutritional values are approximate and may vary based on factors such as variety, cooking methods, and processing.

Table 2 - Barriers to Legume Consumption and Strategies for Overcoming Them

Barriers to Legume Consumption	**Impact and Factors**	**Strategies to Overcome**
Nutritional Benefits vs. Decline in Consumption	- Decline in legume consumption globally, especially in high-income countries - Confusion about serving sizes and health benefits - Grouping with other food categories in dietary guidelines	- Clear directive to consume legumes daily - Educating about health benefits
Psychosocial and Socio-economic Barriers	- Food neophobia: Reluctance to try new legume varieties- Food taboos driven by religious and traditional beliefs - Socio-economic constraints, especially in urban areas	- Promote familiarity with less common legumes - Address cultural and religious beliefs through education - Develop convenient, ready-to-use legume products

Digestibility and Health-related Concerns	- Non-digestible carbohydrates and anti-nutrients causing digestive discomfort- Alpha-galactosides leading to fermentation-related issues- Anti-nutrients reducing nutrient bioavailability	- Implement pre-processing methods like soaking, sprouting, and pulsed electric field - Use extrusion technology to reduce anti-nutritional factors and cooking time - Incorporate legume flour into diverse dishes for palatability
Culinary Techniques and Palatability	- Enhancing the taste and versatility of legume-based foods	- Include legumes in various culinary creations like stews, salads, sprouts, soups, hummus, and desserts - Develop functional food products enriched with legumes using extrusion technology

Note: The strategies mentioned are aimed at addressing the barriers and promoting increased consumption of legumes. The effectiveness of these strategies can vary based on cultural, economic, and individual preference

1